Dynamic of herbaceous biomass during the wet season in the Sahel

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Abstract

The Sahel makes up a transition zone between the extremely dry desert in the north and the sub-humid climate in the south. The vegetation growth in Sahel rangelands is driven by the highly seasonal rainfalls brought by the convective storms of the West African monsoon that reaches the Sahel in rainy season between June and October with a peak rainfall in September. Mean annual rainfall varies from 150 to 600 mm. In adaptation to the regular rainfall seasonality, solar radiation, temperature and air humidity, the herbaceous vegetation is largely dominated by short cycle annual plants, associated with more or less scattered woody plants among which deciduous dominate. Both resources are grazed by livestock in communal rangelands. Annual herbaceous germinate with the first rains, sometimes between May and July, depending on years and locations. Their growth starts slowly for a couple of weeks during which grasses seedlings establish their rooting system and tillers. The growing dynamic of the herbaceous vegetation during the rainy season is, however, not well understood. During the rainy season of 2017 from 24 June to 10 October, the weekly biomass growth of three rangelands plots in Northern Senegal was assessed. The biomass of herbaceous plants was measured using a destructive approach. The first rain in 2017 was quite early (end of June). However, the rain stopped after one month and the second rain wasn't until August. This unexpected rainfall shortage resulted in a cessation of vegetation growth. During this period, the grass did not grow and stayed in early phenological stages.

Keywords: Sahel rangelands, seasonal rainfall, herbaceous vegetation

Introduction

The Sahel region is one of the largest dryland areas in the world. It covers a 6,000 km belt spanning across ten African countries from the Atlantic Ocean to the Red Sea. The Sahel is characterised by low (150 - 600 mm yr^{-1}) and erratic rainfall (CV = 0.30) (L'hote, *et al.,* 2002; Dyer, *et al*., 2016). Extensive livestock production is the main economic activity. Animals mainly feed on natural savanna vegetation composed of scattered trees and an annual herbaceous layer (Hiernaux and Le Houérou, 2006). Herbaceous species grow during the short rainy season (one to three months of rainfall) and are exploited by livestock during both the rainy and the dry seasons. They also provide many other services such as carbon sequestration, soil erosion control, biodiversity conservation. The annual species germinated generally with the first rain. These species continue to grow during the rainy season (one – three months) until flowering, fructification, and then death. The dry grass is consumed by livestock during the dry season. The dynamics of the vegetation during the rainy season is a key parameter for the livestock production in pastoral systems. Understanding the dynamic of the rangeland during the rainy season would be useful knowledge for the prediction of the available biomass. In this work, we present the results of a weekly monitoring conducted during the rainy season from 3 July to 30 September.

Materials and methods

The study area is located in the sylvo-pastoral Ferlo region of Senegal in the Zootechnic research center of the Senegalese agricultural research institute in Dahra Djoloff (15°21' N 15°26' W). Three plots of 20 × 20 m area of natural rangeland were monitored throughout the rainy season of 2017. Two of the

plots (P1, P2) were mainly dominated by *Zornia glochidiata* and the third (P3) by *Diodia scandens.* The monitoring commenced one week after the first rain event of 10 mm on 24 June. Each week, three quadrats of 1 m^2 were randomly placed on each plot. On this quadrat, the fresh herbaceous biomass were collected and dried to obtain the dry biomass. We evaluated the dynamics of the biomass. For each plot, we made an ANOVA to test the difference of biomass at each measurement date followed by a Tukey HSD test. We also calculated the daily gain in dry mass between two measurement dates.

Results and discussion

Figure 1 presents the biomass of the herbaceous mass monitoring during the rainy season and the rainfall events. For each plot, Table 1 presents the quantity of herbaceous mass in dry matter, the daily gain in biomass calculated between two measures. In the 2017 season, first rainfall occurred at end of June (88.5 mm between 24 and 29 June). Thus, between 29 June (day 4 after the first rain) and 27 July (day 34 after the first rain) only 3.5 mm of rainfall was recorded. The first rain induced a germination of the herbaceous

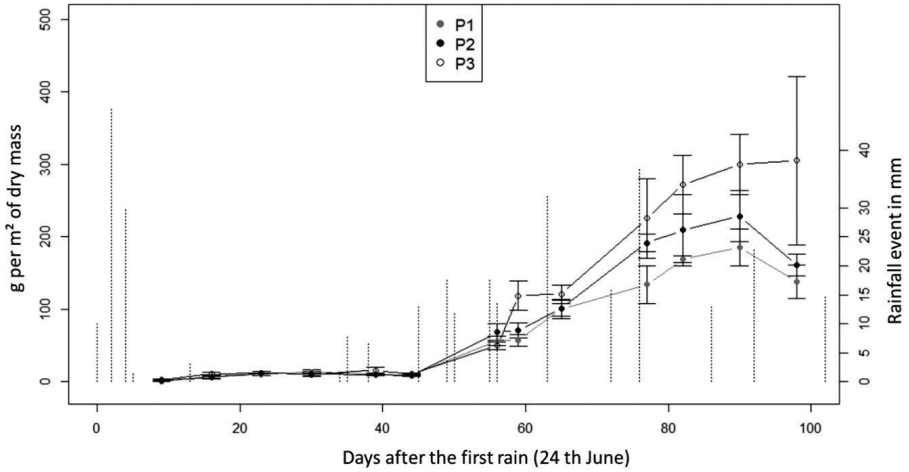

Figure 1. The mean dry biomass dynamic of the three plots [P1, P2, and P3] measured on the research center of Dahra Djoloff at each week after the first rain. Error bars represent the standard deviation. Vertical dotted lines represent rainfall events during 2017.

Table 1. Dry Biomass measured each week in daily gain in biomass. The letters correspond to the results of the Tukey HSD test.

Days after the first rain	Dry mass in g per m^2						Daily gain in g of dry mass		
	P1		P2		P3		P1	P2	P3
9	0.84	a	1.86	a	2.14	a	0.84	1.86	2.14
16	6.91	a	5.73	a	10.83	ab	0.87	0.55	1.24
23	9.77	a	11.98	a	11.65	ab	0.41	0.89	0.12
30	13.49	a	10.71	a	10.09	ab	0.53	-0.18	-0.22
39	9.78	a	9.72	a	15.67	ab	-0.41	-0.11	0.62
44	9.1	a	8	a	10.26	ab	-0.14	-0.34	-1.08
56	56.36	b	68.34	b	49.57	ab	3.94	5.03	3.28
59	57.46	b	70.91	b	118.8	ac	0.36	0.86	23.07
65	100.4	c	101.2	b	121	bc	7.15	5.06	0.37
77	134	cd	191.6	cd	225.4	cd	2.8	7.53	8.7
82	168.9	de	209.1	cd	272.2	d	6.99	3.52	9.37
90	185.8	e	228.3	d	300.1	d	2.11	2.4	3.48
98	138	cd	160.9	c	305.12	d	-5.98	-8.43	0.63

covers. However, the break in the rainfall stopped growth at a biomass of about 10 g m^{-2}, which led to a decrease of the biomass. Between 28 July and 26 August, nine rainfall events occurred totaling 123 mm of rainfall. This induced a quick increase in the herbaceous layers. The growth stopped around day 90 and started to decrease until day 98 for the plots P1 and P2.

These results show that the dynamics of the annual herbaceous are strongly linked to the rainfall events. The reparation and regularity of the rainfall are quite important parameters on the biomass production of rangeland, more so than the sum of rainfall in the year.

In the year 2017, the first rainfall events were not useful for the production of the biomass. The last rainfall also did not contribute to the biomass. Indeed, with annual species, the plants stop growing when flowering and seeding. Continued monitoring will provide a better understanding of the dynamics of the biomass of Sahelian rangelands.

It seems that the best production will be obtained when the rainfall is quite regular during the rainy season. A break during the rainy season has a strong consequence on the biomass production. Furthermore, the rainfall at the end of the season seems to not be useful. An early season will induce a higher biomass than a season with a later start.

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